CONFIDENTIAL

Sixth and Final Bimonthly Report

on the

Miniature IF Amplifier Program

[redacted] 25X1

Prepared by: [redacted] 25X1

[redacted] 25X1

ORIGINAL CL BY 235979
☐ DECL ☒ REVW ON 02/04/2010
EXT BYND 6 YRS BY SAME
REASON 3 d (3)

DOC 8 REV DATE 2 APR 1980 BY 064540
ORIG COMP 056 OPI 56 TYPE 30
ORIG CLASS M PAGES 21 REV CLASS C
JUST 22 NEXT REV 2010 AUTH: HR 70-2

CONFIDENTIAL

Declassified in Part - Sanitized Copy Approved for Release 2012/02/15 : CIA-RDP78-03424A000500050019-3

TABLE OF CONTENTS

		Page No.
I.	Purpose	1
II.	Abstract	1
III.	Factual Data	2
	1. The Ceramic Resonator Amplifier	2
	2. The Crystal Filter Amplifier	5
IV.	Conclusions	8
V.	Future Plans	9
VI.	Identification of Key Personnel	10

I. Purpose

The purpose of this program was stated in the First Bimonthly Report as being to bring to fruition work previously carried out in the development of IF amplifiers using novel techniques and devices. In particular two amplifiers were to be constructed, one employing a crystal filter for selectivity while the other was to use ceramic transformers for interstage coupling and selectivity. The objectives of this program, as described in some detail in the First Bimonthly Report, have remained unchanged.

II. Abstract

This report gives a description of the completed amplifiers including the final circuit diagrams, performance characteristics, etc. The final dimensions of the ceramic transformer amplifier are 2.06" x 1.65" x 0.65" giving a volume of approximately 2.2 cubic inches. These are the outside dimensions of the package. Similarly, the outside case dimensions for the crystal filter amplifier are 1.95" x 2.35" x 1" giving a volume of approximately 4.5 cubic inches. This is appreciably larger than the "slightly over 2 cubic inches" anticipated in the proposal. Difficulty was experienced in fabricating the filter itself in the original volume which was allotted to it. Furthermore, in order to make the complete package of a compact form factor some space, within the package, had to be wasted. In an actual receiver, where an "in line" type of layout would be used, adequate separation between filter input and output connections could be ensured without incurring this waste of space.

The electrical performance of both amplifiers, as reflected in data included in this report, came close to that predicted. Information is given concerning power drains, bandwidth, power gain, temperature behavior, spurious responses (in

the case of the ceramic resonator amplifier since it includes a mixer and a local oscillator), input and output impedances, etc. Appropriate photographs of the unit are also included.

III. Factual Data

1. The Ceramic Resonator Amplifier

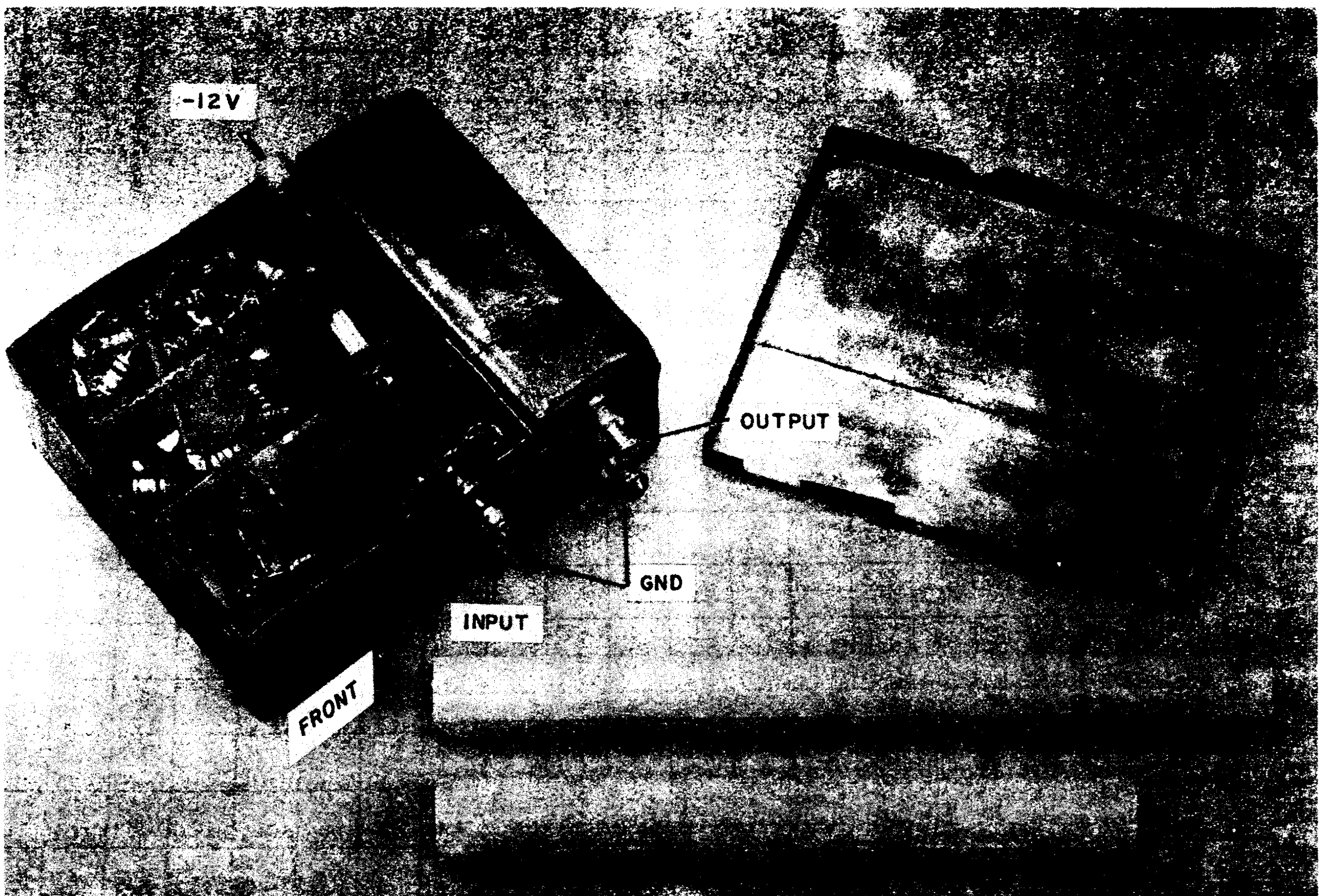
(i) General Description of the Amplifier

The completed miniaturized ceramic resonator amplifier is constructed in three sections, as shown in Figure 1. The 2.28 mc image rejection filter lies along the front of the case and occupies a volume of approximately 0.5 in^3. The 2.28 mc IF amplifier, 2.736 mc crystal controlled oscillator and mixer portion is in the rear section of the case. The 455 kc ceramic resonator amplifier lies along the left side in a shielded enclosure of 0.6 in x 0.6 in x 1.4 in (shown separately in Figure 1A). The overall dimensions of the outside container, excluding terminals are 1.65" x 2.05" x 0.67" or 2.25 cu. in.

The battery drain is 2 ma from a-12 volt source or approximately 25 millwatts for the six transistors. Connection is made to the single terminal at the rear of the case.

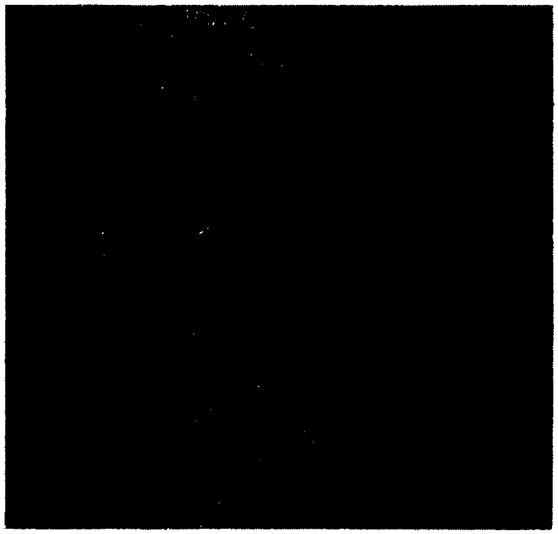
The incoming signal from the image filter (see Figure 2) is amplified by a broadly tuned 2.28 mc amplifier before being converted down to 455 kc in the mixer stage. The 2.736 mc crystal controlled local oscillator is transformer coupled into the base of the mixer whose conversion gain is relatively constant for a range of oscillator injection voltages of from 40 to 100 mv.

The output of the mixer is fed directly into the input ceramic resonator of



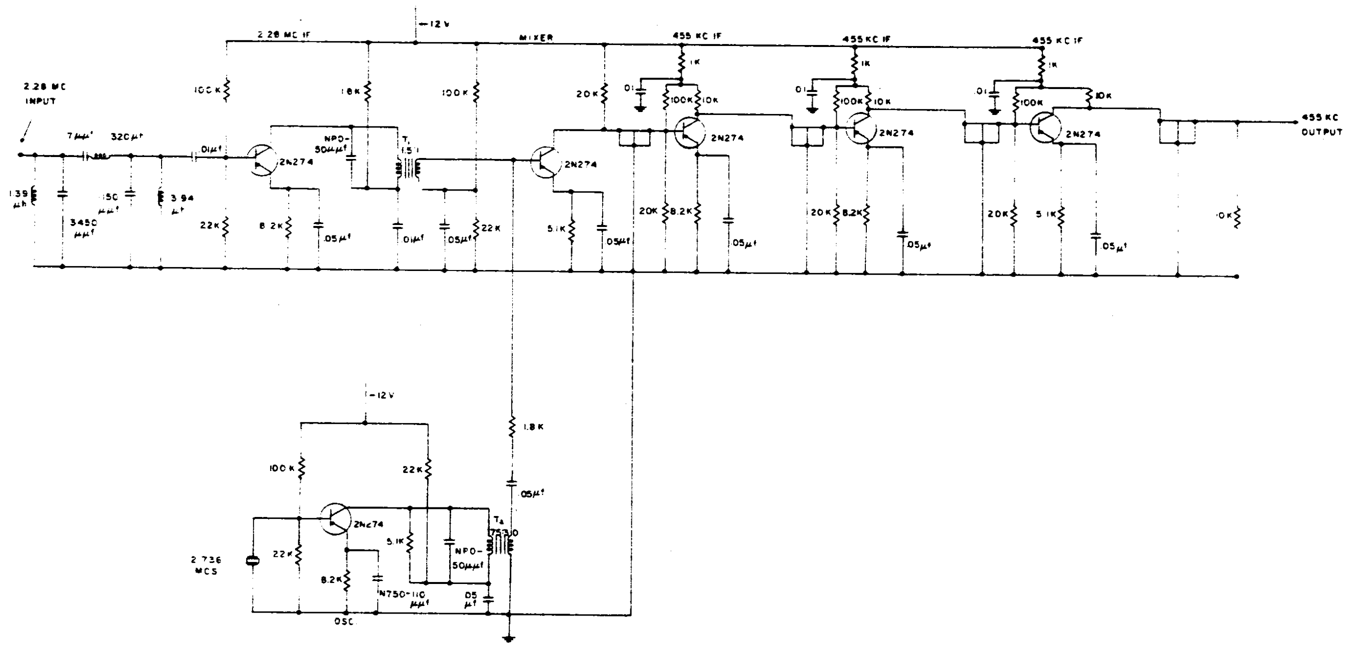
LAYOUT OF CERAMIC RESONATOR AMPLIFIER

FIGURE I



455KC AMPLIFIER USING
CERAMIC TRANSFORMERS

FIGURE 1A



SCHEMATIC DIAGRAM OF CERAMIC RESONATOR AMPLIFIER

FIGURE 2

the final three stage amplifier which is contained in a separate shielded copper box, 1.5" x 0.6" x 0.6" or .54 cu. in.

The lumped filter is required to provide adequate image rejection at the mixer output. For a local oscillator frequency of 2.736 mcs and a low IF frequency of 455 kc, the image frequency is 3.19 mcs. Sufficient rejection of this frequency must be provided in front of the mixer since any 3.19 mc component reaching the base of the mixer will be converted along with the desired 2.28 mc signal. The three tuned circuits of the filter, in conjunction with the tuned output of the 2.28 mc amplifier, provide over 60 db of image rejection. The three transformers are 0.25" OD ferrite torroids of [redacted] wound with No. 36 25X1 wire. The input and output capacitors are Mylar film type, chosen to compensate for the temperature variations of the transformer cores. The bandwidth of the filter is approximately 150 kcs at the center frequency of 2.28 mcs. The input impedance of the filter is 400 ohms.

(ii) Performance of the Ceramic Resonator Amplifier

The overall power gain of the complete amplifier is 89 db at an input signal level of 5 μv. The final three stages, employing the ceramic resonators, furnish 63 db gain.

The bandwidth of the finished low frequency amplifier operated under small signal conditions is 5.6 kc. The bandwidth of the entire amplifier varies with the input signal level as shown in Table 1.

The bandwidth of the overall amplifier is wider than that of the low IF amplifier particularly at higher signal levels. This is caused by partial limiting in the final stage due to the high gain and the lack of a second detector and a closed loop

Input Level μv	Bandwidth kcs
1.2	11.7
5.0	14.9
20	21.2

Table 1. Change in Bandwidth with Input Signal

automatic gain control system.

The integrated noise output voltage measured by a wide band voltmeter is 0.22 to 0.25 volts. The output as measured by a 455 kc narrow band voltmeter is 0.1 volts.

The following spurious responses appear in the output for an input signal of 8 μv which gives 0.9 volt output.

2.736 mc (local osc. freq)	0.9 mv
2.28 mc (input freq)	0.1 mv
.820 mc	.5 mv
.910 mc (2 x 455 kc)	2.0 mv

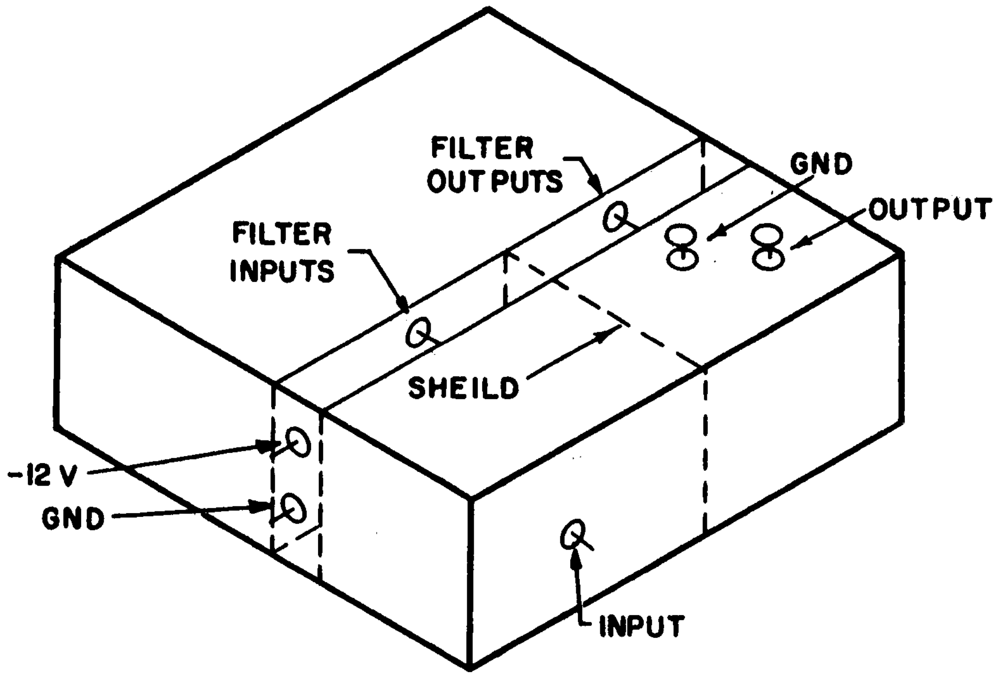
(iii) Temperature Performance of the Amplifiers

The variation of center frequency at -40°C is +1.5 kc from the room temperature value. The gain drops 5.5 db at -30°C and -40°C. Due to time limitations, this rather rapid decrease in gain between -30°C and -40°C was not investigated fully; however, it is probably caused by mistuning of the filter or by a change in the oscillator injection voltage. The gain increased 1.3 db at +40°C.

2. The Crystal Filter Amplifier

(i) General Description of the Amplifier

The completed 2.28 mc amplifier employing a crystal filter with a bandwidth of 5 kc is contained in a shielded case 1.95" x 2.35" x 1" or 4.58 cu in. The crystal filter measures 2" x .8" x 1.2" or 1.9 cu. in. and the four stage transistor amplifier occuplies a volume of approximately 1.25 cu. in. The remaining 1.4 cu. in. is unuseable space between the amplifier, filter and the outside case. Figure 3 shows the layout and interconnections of the amplifier and crystal filter. In realizing a compact form factor considerable space is wasted between the two units.



TERMINAL DIAGRAM OF FILTER AMPLIFIER

FIGURE 3

In an actual receiver layout, it should be possible to provide adequate isolation between the filter input and output circuitry without incurring this wasted space by using a more elongated form factor. In the present version partial use of this space has been made by accomodating a decoupling circuit between the input and output sections of the amplifier in the -12 volt line. Figure 4 shows a photograph of the amplifier when partially wired. The schematic diagram of the amplifier is shown in Figure 5 and that of the crystal filter in Figure 6.

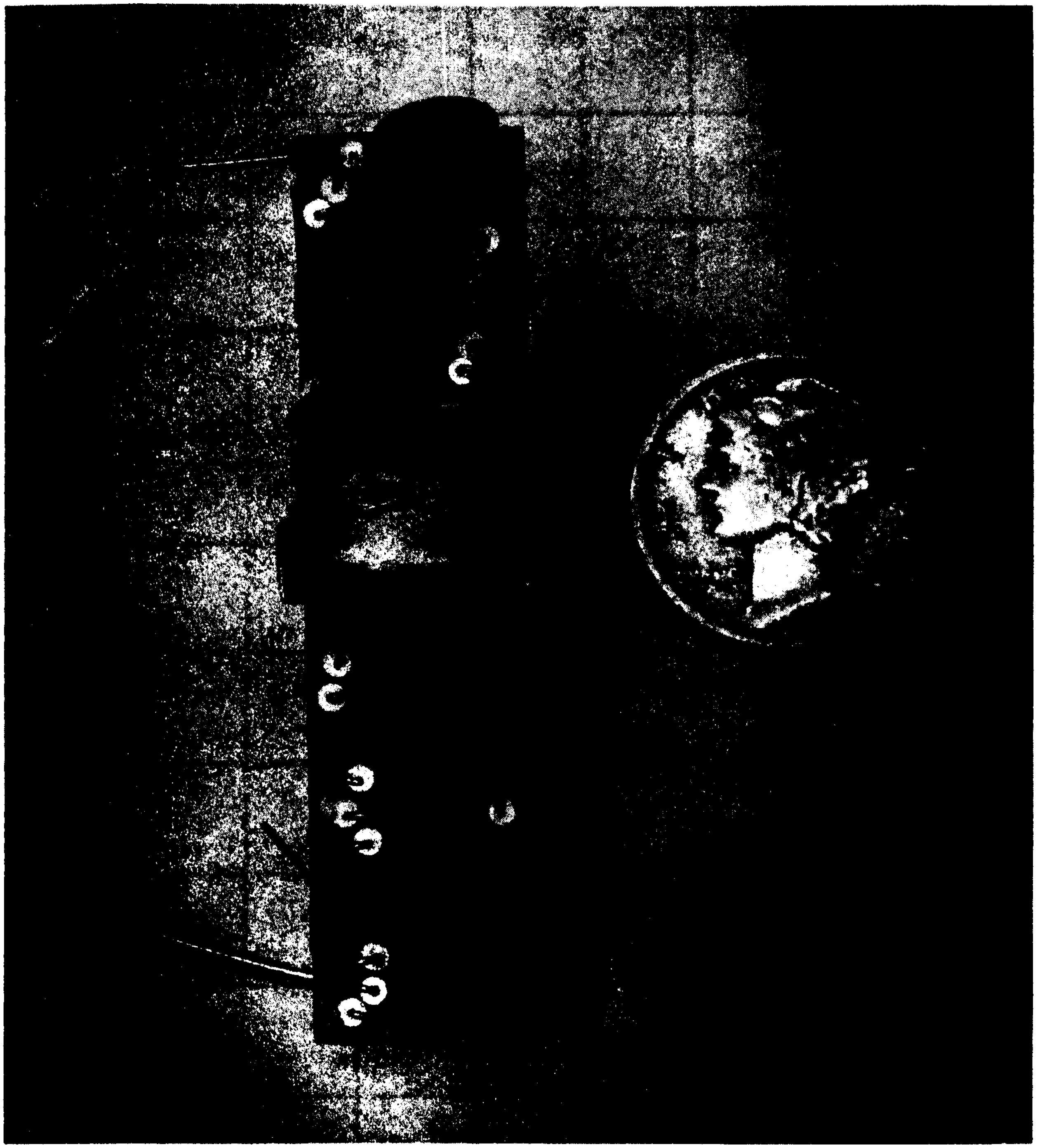
The three transformer cores used in the amplifier are of [redacted] 25X1 CQ-64 material, 0.25" OD. The turns ratio is shown on the circuit diagram, the windings being of No. 36 wire.

The cores are encapsulated in 0.375 inch diameter E-Case Shells and sealed with Epoxy Products No. 2200 Liquid Resin. The units are then partially shielded with silver conductive paint. Complete shielding would result in a severe drop off in Q due to the close proximity of the shield to the transformer windings in such a small package.

A precaution to be observed in the use of these CQ-64 cores is to limit the amount of dc current through the winding at all times to a value below that required to saturate the core. Once the core is saturated the inductance and Q will remain changed unless the core is properly demagnetized. It should be noted that the current supplied by an ordinary ohmmeter on the lower ranges is sufficient to saturate the cores.

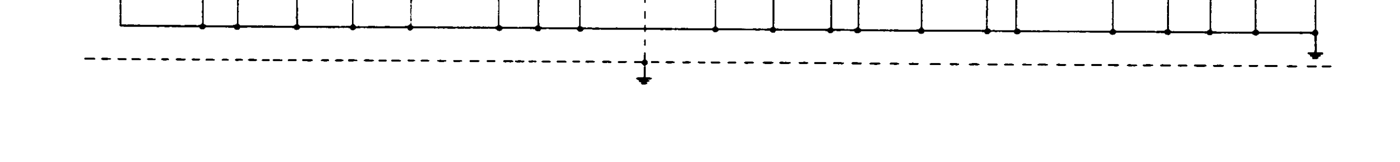
The input and output transformers of the filter are 0.685" OD torroids manufactured by Radio Cores, Inc., Part No. 57 - 1677 - 4. The four crystals are

[redacted] 25X1



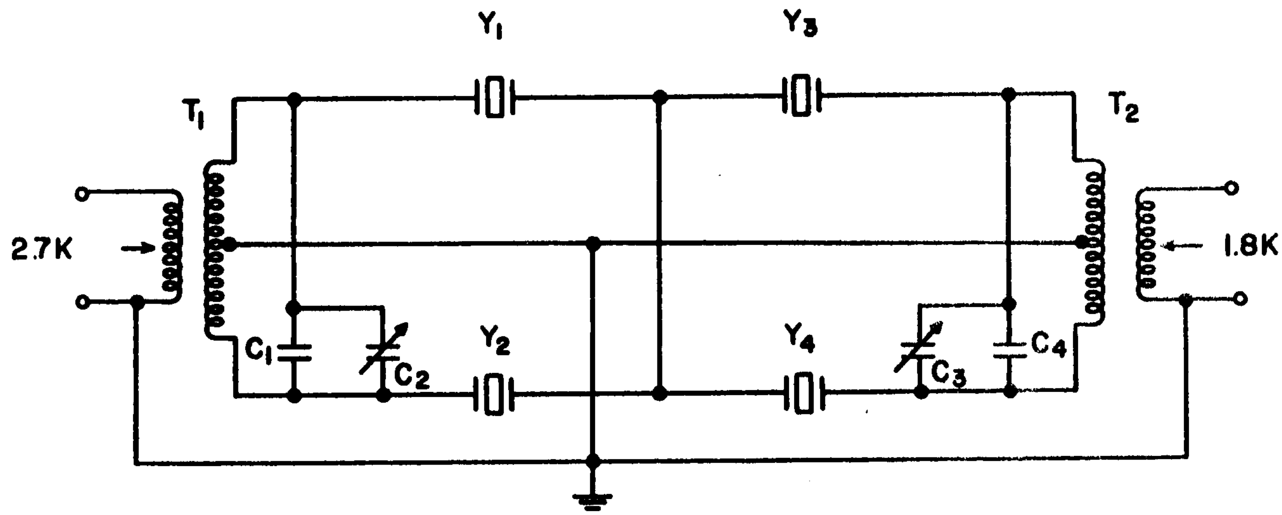
PHOTOGRAPH OF FILTER AMPLIFIER

FIGURE 4

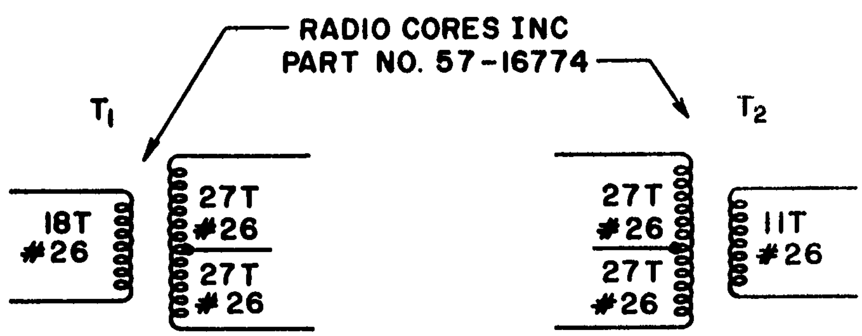


2.28 MCS CRYSTAL FILTER IF AMPLIFIER

FIGURE 5



	SERIES RESONANT FREQ	C_u	C_1
Y_1, Y_4	2.281 MC	2.5$\mu\mu$f	.007$\mu\mu$f
Y_2, Y_3	2.2785 MC	2.5$\mu\mu$f	.0075$\mu\mu$f



C_1, C_4 = 270$\mu\mu$f

C_2, C_3 = .8-8$\mu\mu$f

GLASS TRIMMER JFD VC9GW

CIRCUIT DIAGRAM OF 2.281 MC FILTER

FIGURE 6

(ii) Performance of the Lumped Filter Amplifier

The battery drain of the Lumped Filter Amplifier is 1.4 ma at -12 volts or 16.8 milliwatts. The input impedance of the amplifier is 1200 ohms while the output impedance is 3000 ohms.

The overall power gain of the amplifier including the insertion loss of the filter is 72 db for an input signal level of 5 μ v.

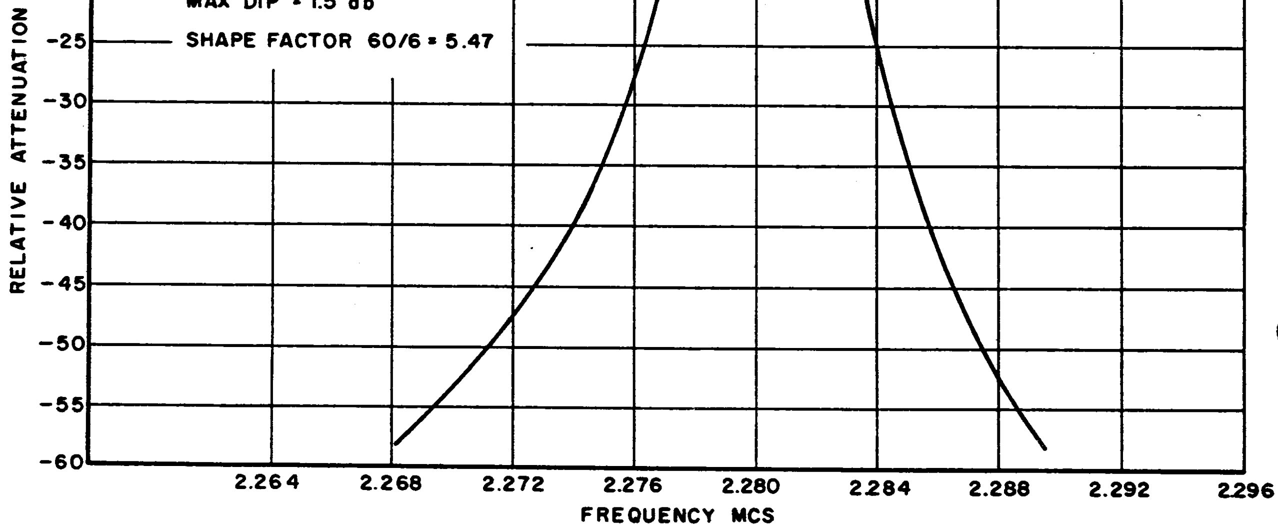
Considerable difficulty was encountered in preventing oscillation due to feedback from the output section to the input. The two sections are separated by a multiple shield of copper and iron. Due to circuit layout of the amplifier, necessitated by the terminal locations of the filter, the imput and output transistor stages are adjacent on the board. It was thus not possible to locate the input and output leads at opposite ends of the case.

Over the temperature range of -40° to $+40^{\circ}C$ the gain variation is +1.5db at $+40^{\circ}C$ and -10 db from 0° to $-40^{\circ}C$.

The passband of the filter operating between source and load resistances of 2.7K and 1.8 K ohms is shown in Figure 7. The 3 db bandwidth is 4.4 kc and the 60/6 db shape factor is probably better than the observed value of 5.5 which was measured under high noise conditions which tend to widen the base of the response curve. The insertion loss between resistive terminations if 6.4 db and the maximum passband dip measured from the peak is 1.5 db.

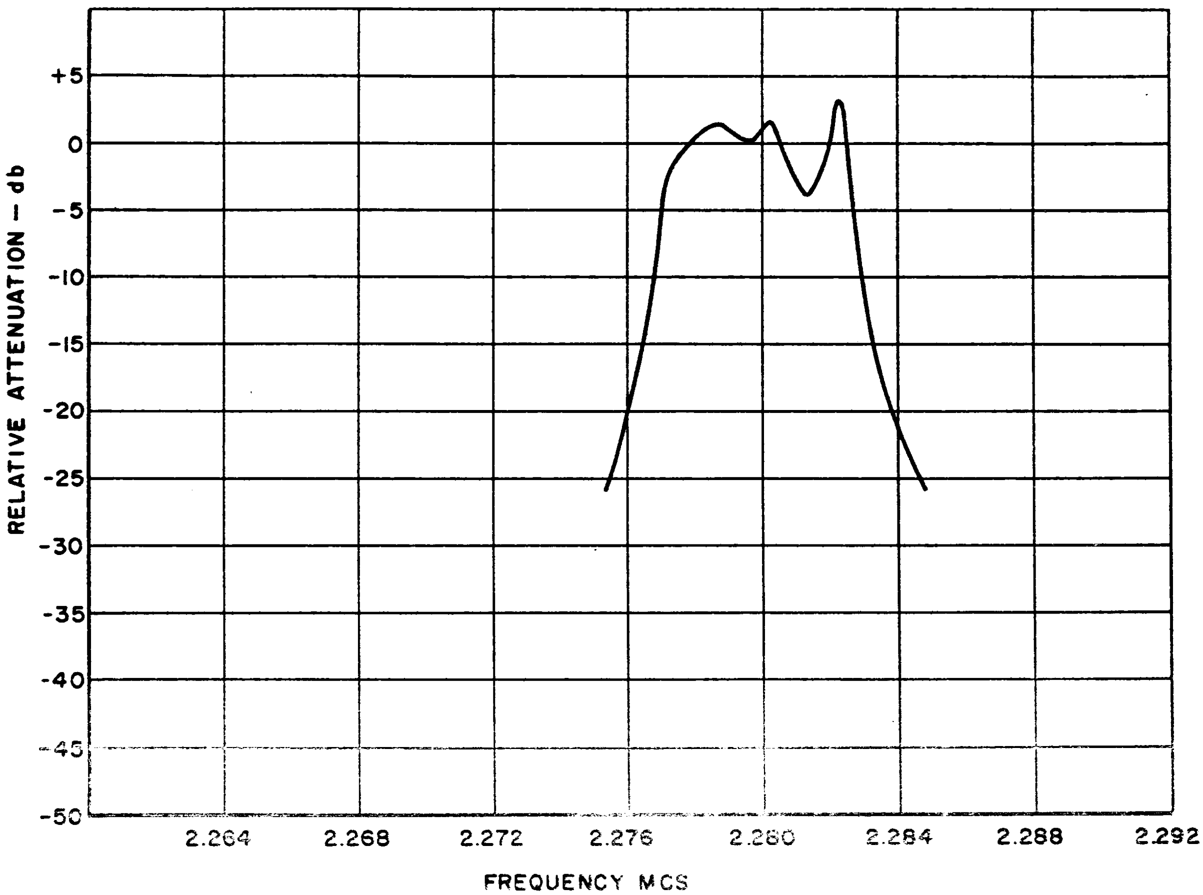
The response curve for the amplifier is shown in Figure 8. The loading capacities of the transistor stages and the regenerative feedback around the filter combine to distort the passband as shown, with a dip of 4 db and a peak of 3 db at the edge of the passband. The 3 db bandwidth other than this is 5.4 kc. The

7A



RESPONSE OF FILTER WITH RESISTIVE TERMINATIONS

FIGURE 7



RESPONSE OF FILTER AMPLIFIER

FIGURE 8

insertion loss of the filter in the amplifier increased to 15 db because of impedance mismatch due to capacitive loading and realignment to reduce the passband distortion.

IV. Conclusions

1. The Ceramic Resonator Amplifier

As may be seen from the previous section of this report a considerable quantity of data has been taken on the performance of the amplifiers. This information serves to show the extent to which the original performance objectives have been met and the areas where further effort is indicated. The advisability of undertaking such work is, of course, a function of the extent to which the original specifications represent actual "system" requirements. For example, probably the most apparent shortcoming of the present amplifier is its decrease in gain at very low temperatures. On the other hand, it is questionable whether such a high gain is really desirable in the first place due to the severe dynamic range limitations which result. This problem would be eased in an actual receiver by the inclusion of automatic gain control.

From the standpoint of mechanical considerations, the outside case dimensions slightly exceed 2 cubic inches. In an actual receiver, this case would not be required and the circuitry could be contained in the two cubic inches originally intended.

A more significant mechanical consideration is that of a more satisfactory method of mounting the ceramic transformers. The technique used in the present amplifier is based on putting a square ceramic bar in a round hole drilled in a polystyrene block so that the bar is held only by its corners. This method gives satisfactory results for experimental equipment but does not appear to be ideally suited to more rugged applications. The difficulty experienced in mounting these devices arises from the necessity of avoiding mechanical damping which would seriously alter the electrical behavior of the transformers.

2. The Crystal Filter Amplifier

The crystal filter designed for this amplifier was, in final form, appreciably larger than had originally been anticipated. This fact naturally led to a considerably larger overall package than had originally been considered necessary. Furthermore, as explained in the previous section, in order to make the complete package of reasonably compact form factor, it was necessary to waste additional space, in order to provide some degree of insolation between the circuitry at the input and output of the filter. In an actual receiver this wasted space could probably be avoided by using an "in line" form factor.

Some difficulty was experienced due to ringing which was associated with the extremely sharp skirt selectivity provided by the crystal filter. As mentioned previously, the question arises concerning the extent to which the target specifications represent actual requirements from an overall system point of view. The skirt selectivity specified may be necessary in order that a complete receiver operate in the desired manner. On the other hand, it is recalled that these specifications were generated by taking overall receiver selectivity requirements and endevouring to achieve them all at one place, namely in the crystal filter. In an actual receiver some help would be obtained as a result of tuned circuits in the RF and mixer stages.

V. Future Plans

Since this is the final report, there are, at present, no future plans.

VI. Identification of Key Personnel

See previous Bimonthly Reports.